Royal Netherlands
Meteorological Institute
Ministry of Infrastructure and the Environment

Stability of the Ozone Monitoring Instrument

Pepijn Veefkind veefkind@knmi.nl
Quintus Kleipool

Outline

- Introduction to the OMI instrument
- Row anomaly
- Thermal stability
- CCD stability
- Spectral stability
- Radiometric stability

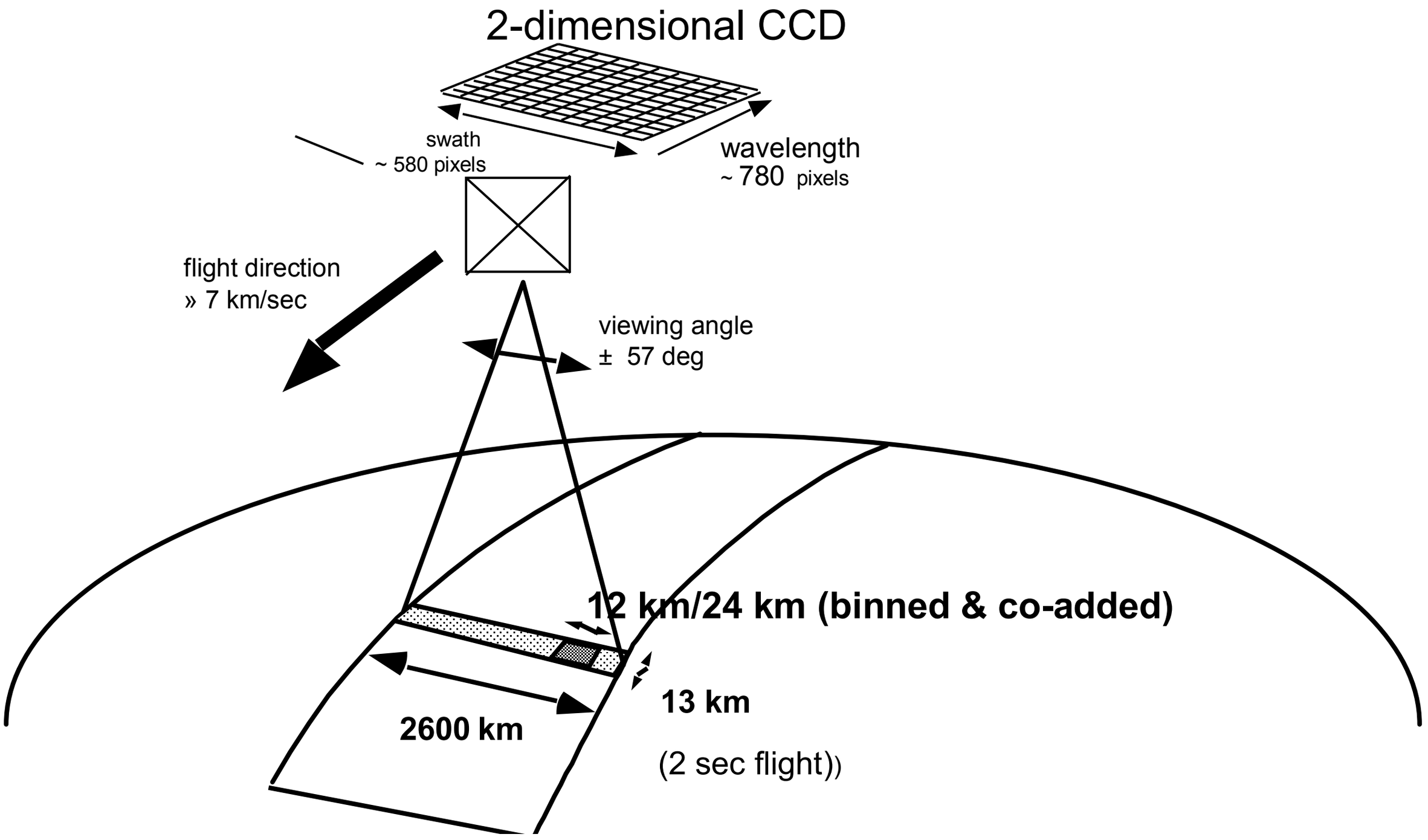
Ozone Monitoring Instrument

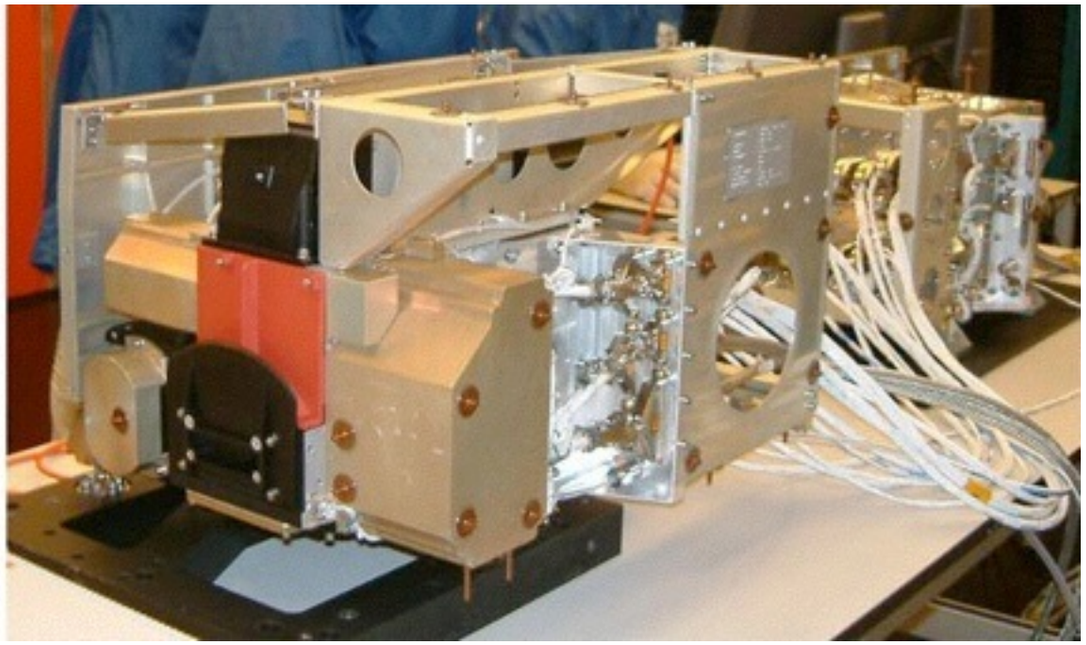
Ozone Monitoring Instrument

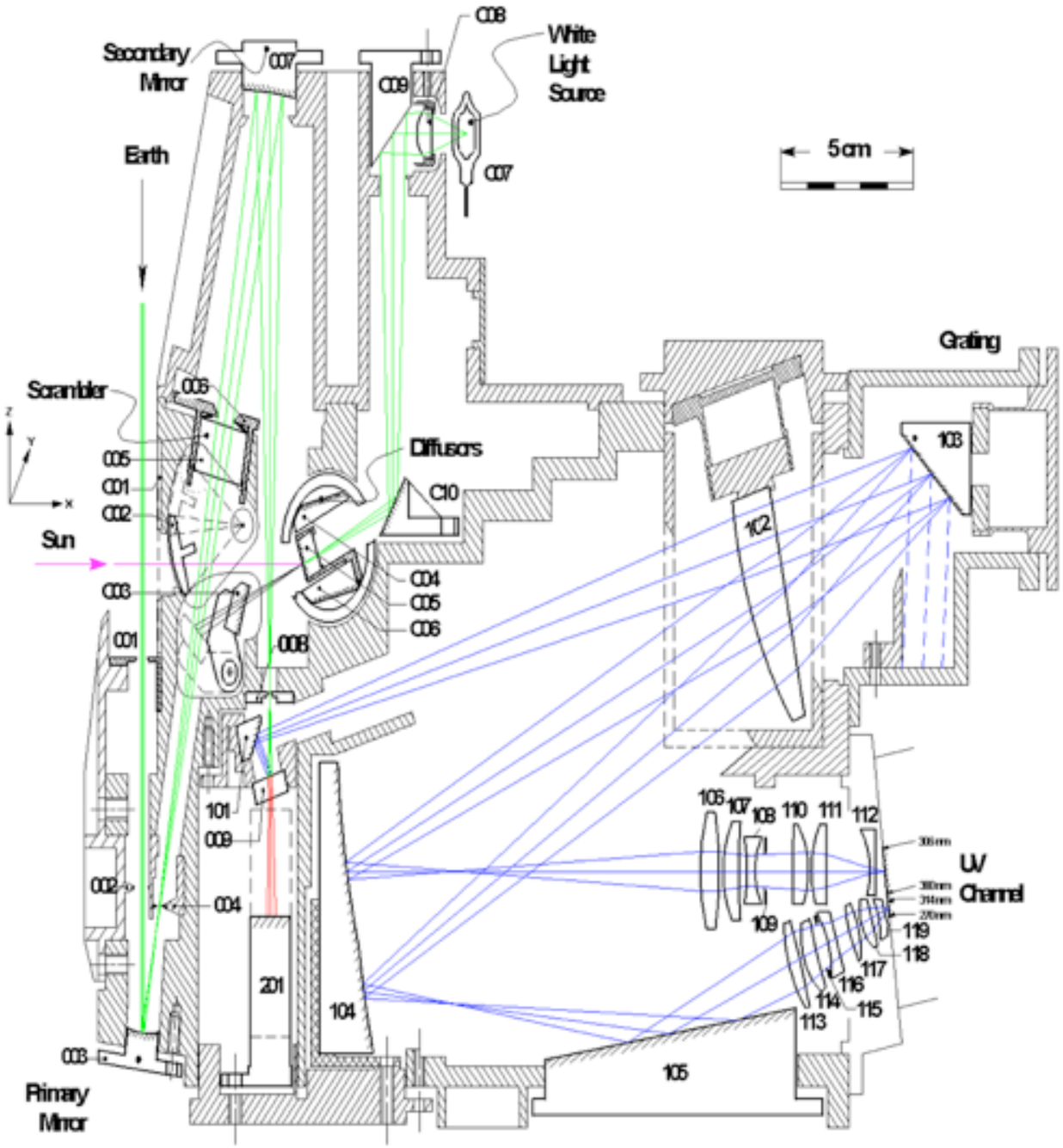
Instrument	Imaging spectrometer
Spectral Range	270 - 500 nm
Spectral Resolution	0.45 - 0.63 nm
Spectral Sampling	0.15 - 0.30 nm
Spatial Resolution	13x24 km
Swath Width	2600 km
Mass	65 kg
Size	50 cm × 40 cm × 35 cm
Power	66 W
Data rate	0.8 Mbps (average)
Spacecraft	NASA EOS-Aura
Launch Date	15 July 2004
Orbit	Sun synchronous, 13:30 hr
Altitude	705 km
Agencies	NSO (NIVR), FMI
PI Institutes	KNMI, FMI

OMI is the Dutch-Finnish contribution to the NASA EOS-Aura Mission and is developed by an international consortium led by Dutch Space and TNO.

OMI Measurement Principal







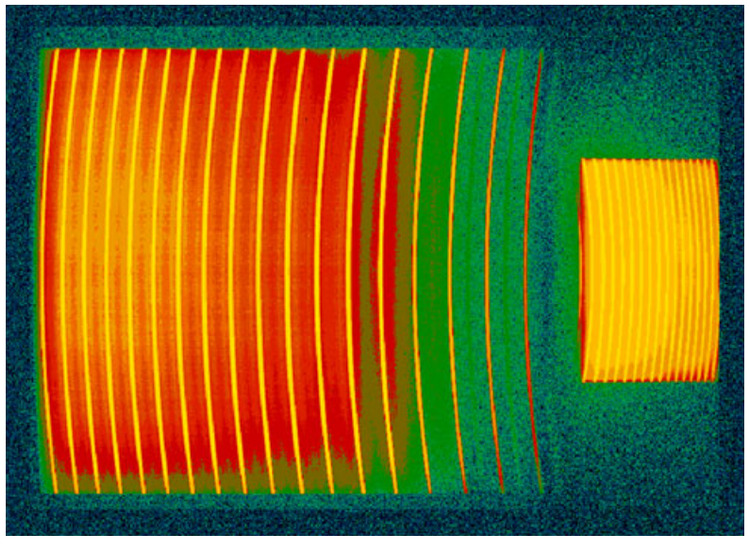
Spectral range, resolution and sampling distances

Channel	Total Range	Full Performance Range	Average Spectral Resolution (FWHM)	Average Spectral Sampling Distance
UV-1	264 - 311 nm	270 - 310 nm	0.63 nm	0.33 nm/pixel
UV-2	307 - 383 nm	310 - 365 nm	0.42 nm	0.14 nm/pixel
VIS	349 - 504 nm	365 - 504 nm	0.63 nm	0.21 nm/pixel

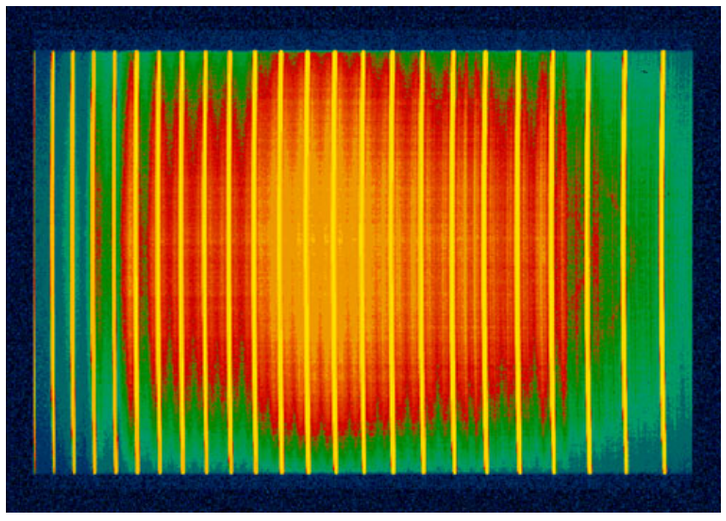
OMI CCD Detectors

- OMI has 2 Frame Transfer CCDs of 780 rows by 576 columns.
- Around the detector modules 10 kg of aluminium shielding has been applied.
- On the CCD 8 detector pixels are binned in the across track direction into one ground pixel.
- In the flight direction 1-4 CCD exposures are co-added.
- Detector temperature is -8 °C.

UV2

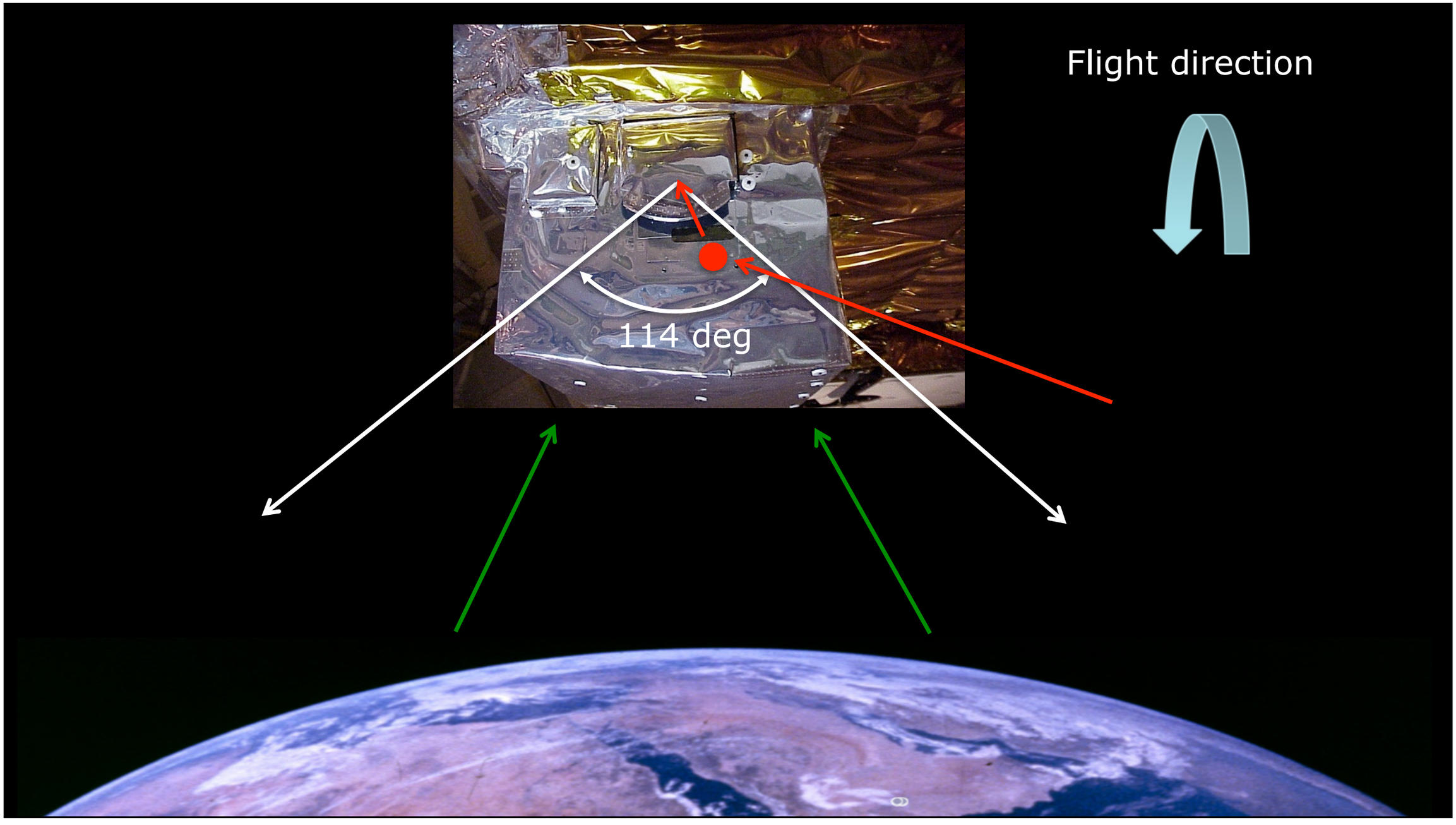


UV1



VIS

Row Anomaly



Errors in L1b caused by the row anomaly

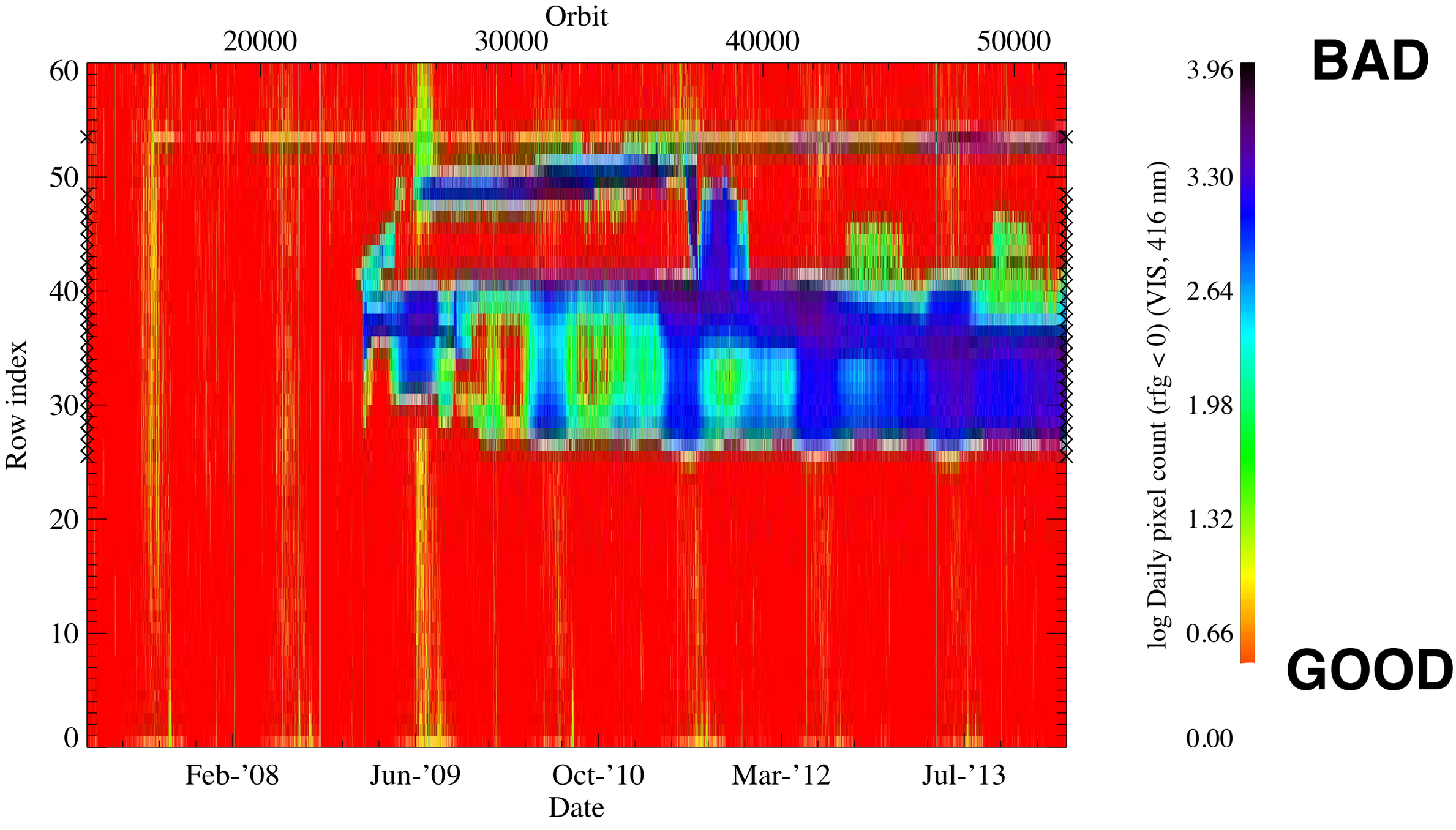
- **A multiplicative error**
  Caused by the partial blockage of the nadir field of view resulting in reduced radiance levels for specific rows.

- **A wavelength shift**
  Caused by inhomogeneous illumination of the spectral slit due to the blocking material, resulting in a change of the slit function.

- **Stray earthlight related additive error**
  Caused by earthlight, reflected by the blocking material from outside the OMI fov into the nadir port.

- **Stray sunlight related additive error**
  Caused by sunlight, reflected by the blocking material into the nadir port for part of the orbit.

Number of negative reflectances (VIS, 416 nm) (Blockage)



Instrument thermal control and stability

	2004	2014	trend
Optical bench	264.00 K	265.20 K	+1.20 K
UV electronics ELU	290.00 K	290.90 K	+0.90 K
VIS electronics ELU	291.50 K	292.30 K	+0.80 K
AUX electronics ELU	289.50 K	290.30 K	+0.80 K

CCD thermal control and stability

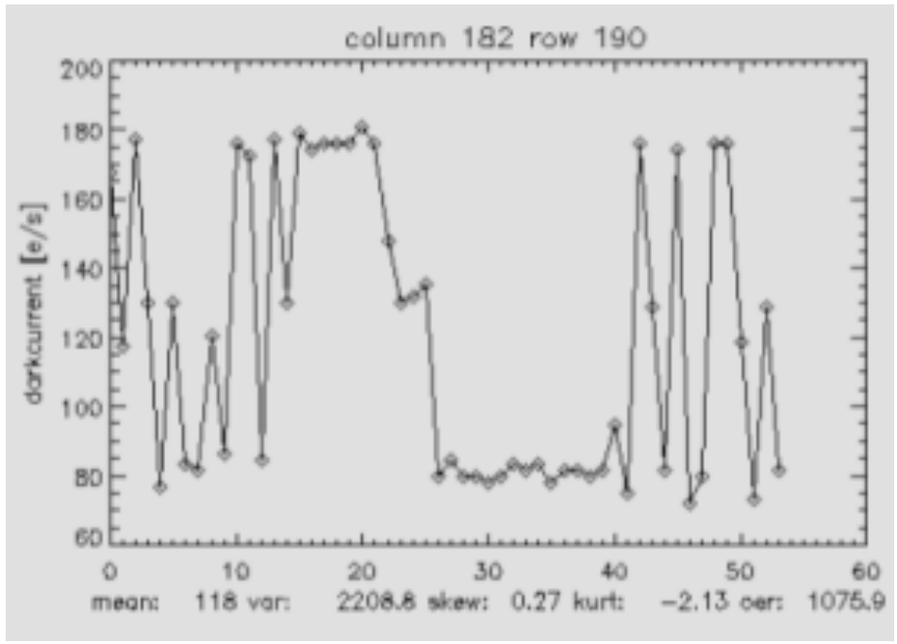
	2004	2014	trend
UV channel CCD	265.13 K	265.18 K	+0.05 K
VIS channel CCD	265.21 K	265.26 K	+0.05 K
UV CCD ATC PWM	20 %	5 %	-15 perc
VIS CCD ATC PWM	24 %	10 %	-14 perc

- OMI has never been switched off over 10 years
- Near-perfect detector temperature control
- PWM margin can last until end of mission

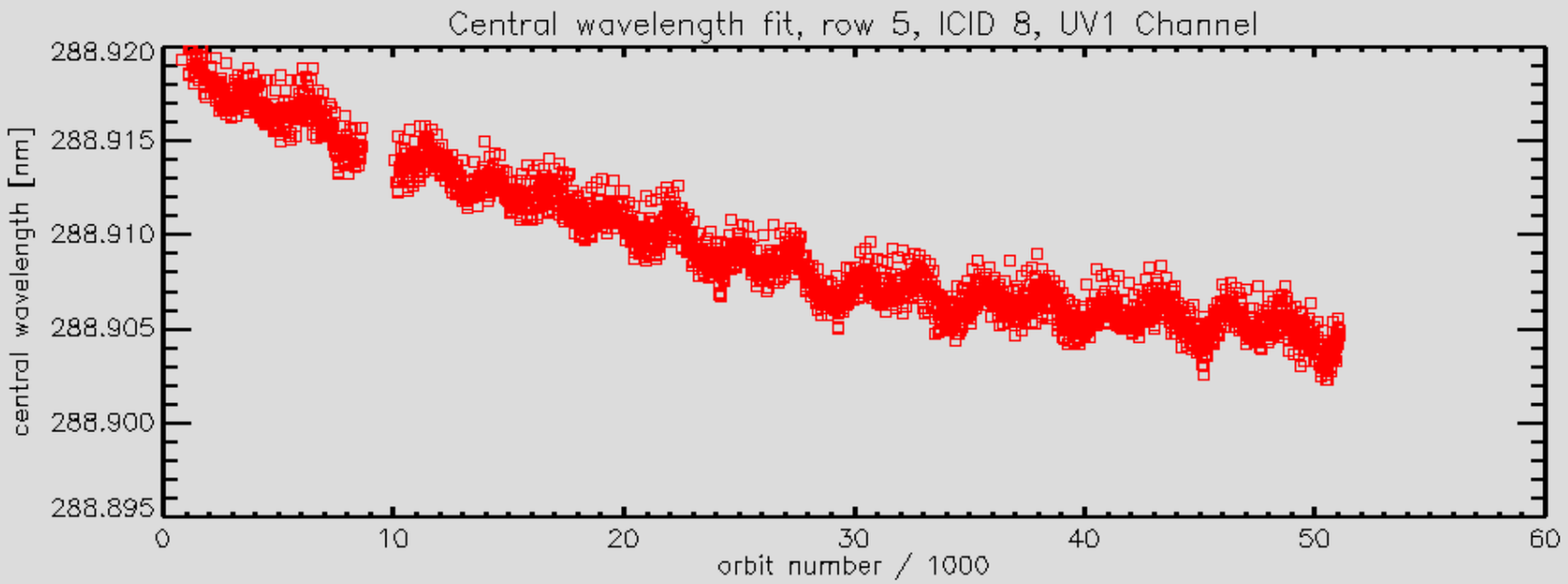
CCD pixel quality statistics (binned)

	UV1			UV2			VIS		
	TROP	MIDLAT	ARCTIC	TROP	MIDLAT	ARCTIC	TROP	MIDLAT	ARCTIC
BAD	7%	16%	20%	6%	6%	6%	7%	7%	7%
RTS	5%	5%	5%	5%	5%	5%	5%	5%	5%

- Detector degradation mainly occurs in SAA and polar belts
- Degradation on individual pixel level
- Caused by CCD bulk radiation damage by protons
- Shows increased darkcurrent
- Shows increased RTS



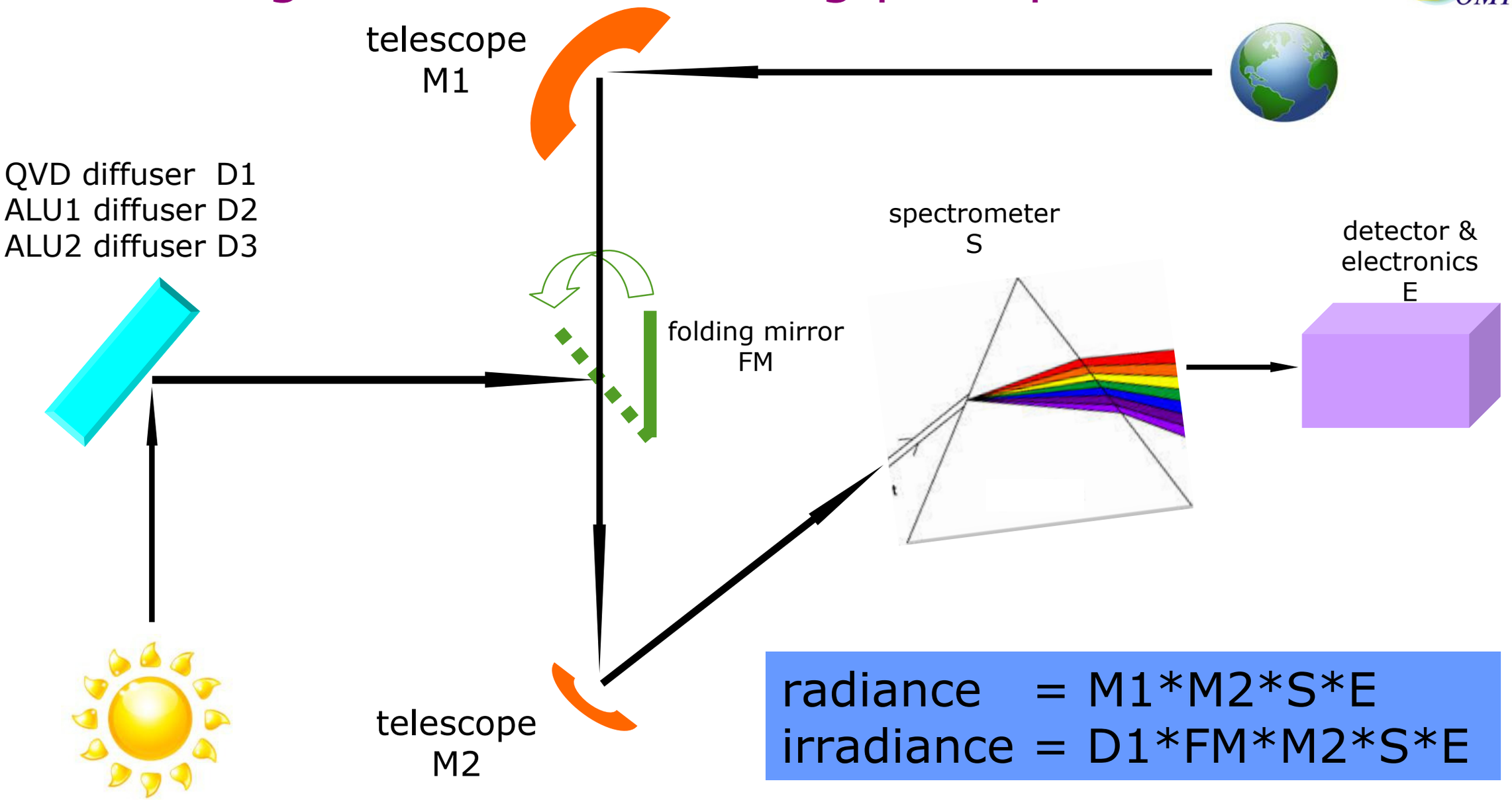
Wavelength calibration monitoring



- spectral stability in general good
- folding mirror anomaly from 28/02/2006 to 11/06/2006
- row anomaly
- spectral calibration switched on in L01b processor

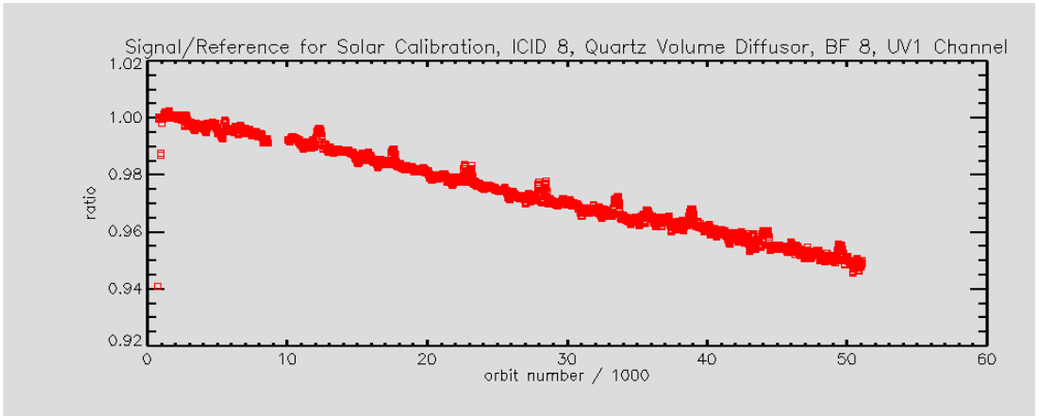
	UV1	UV2	VIS
trend	0.015 nm	0.000 nm	0.001 nm
seasonal [pp]	0.002 nm	0.002 nm	0.002 nm

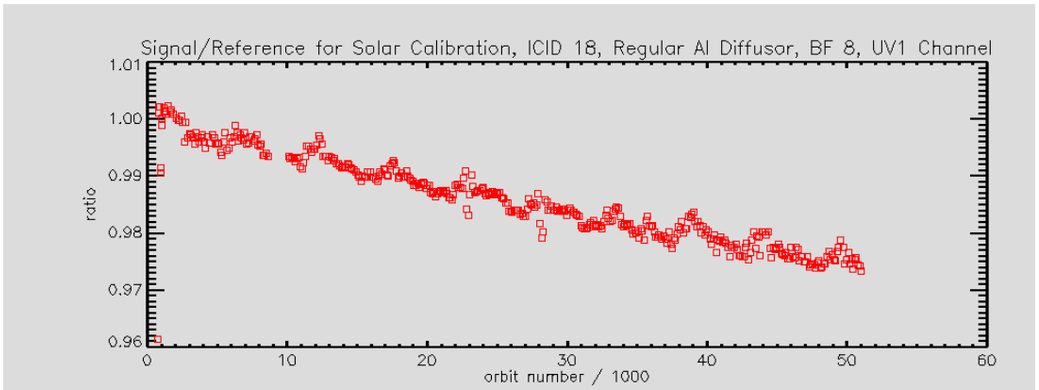
OMI degradation monitoring principle

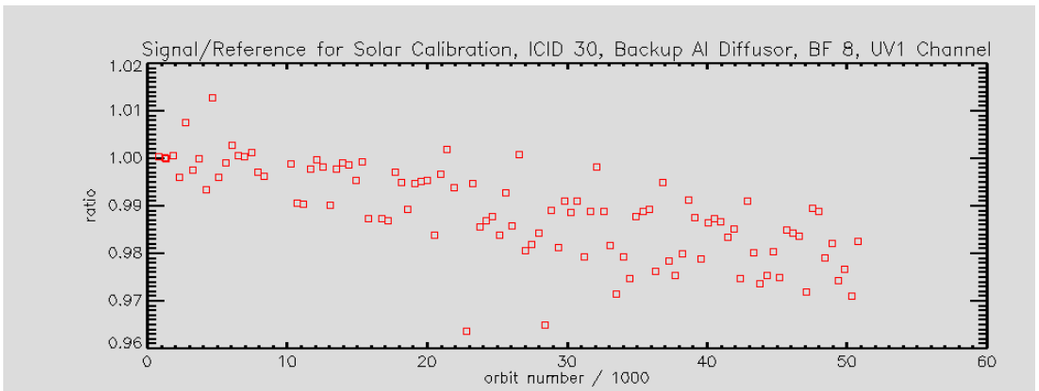


radiance = M1*M2*S*E
irradiance = D1*FM*M2*S*E

Irradiance monitoring



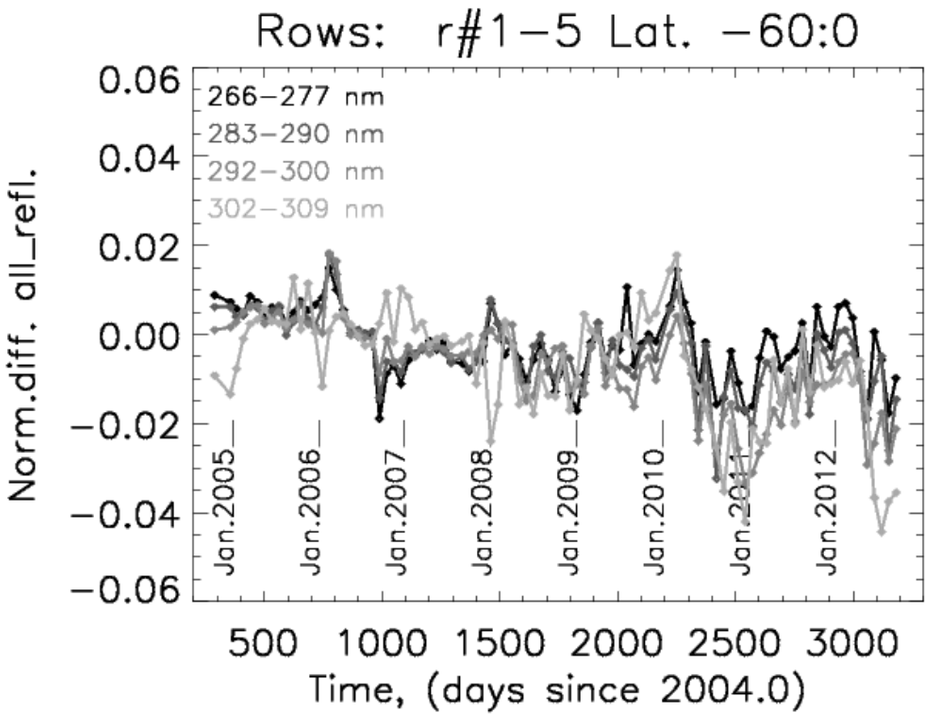


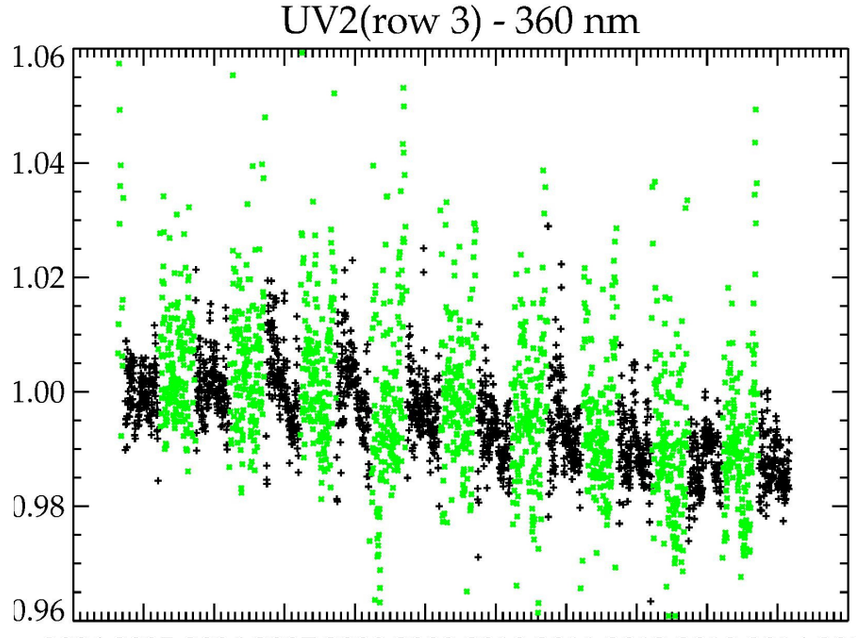


- QVD ➔ daily
- ALU1 ➔ weekly
- ALU2 ➔ monthly
- Degradation includes D1 * FM * M2 * S * E
- Exposure based degradation
- Backup ALU does not degrade
- Degradation may include electronic effects

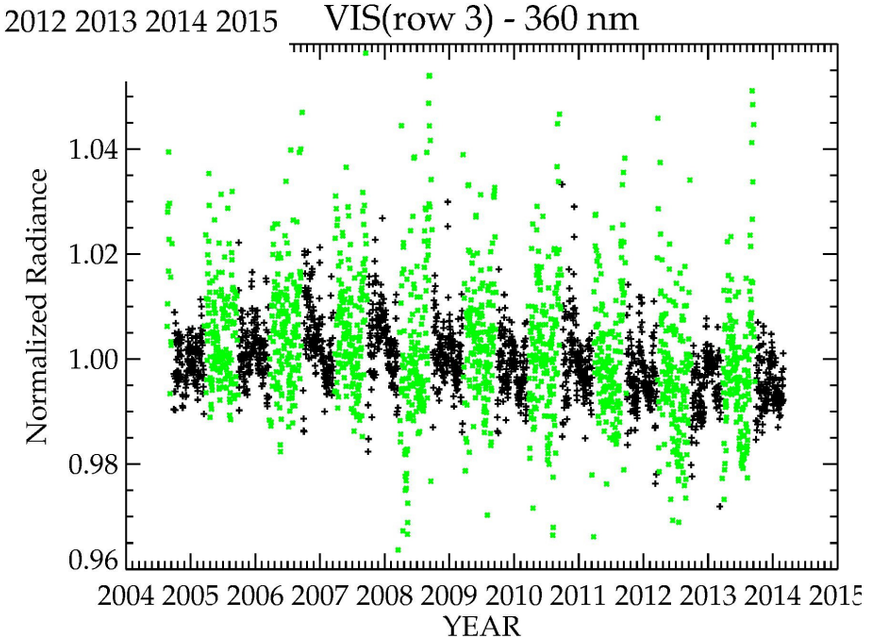
	UV1	UV2	VIS
QVD path	0.955	0.970	0.977
ALU1 path	0.974	0.982	0.981
ALU2 path	0.980	0.984	0.983
QVD total	-4.5 %	-3.0 %	-2.3 %
QVD	-2.5 %	-1.4 %	-0.6 %
other inc FM	-2.0 %	-1.6 %	-1.7 %

Radiance monitoring





UV1 : -1.0%
UV2 : -0.5%
VIS : -0.5%



- Antarctic and Greenland Ice sheet reflectance model
- De-trended zonal ozone averages
- Degradation includes M1 * M2 * S * E
- Set of equations cannot be solved without assumptions or detailed model for degradation

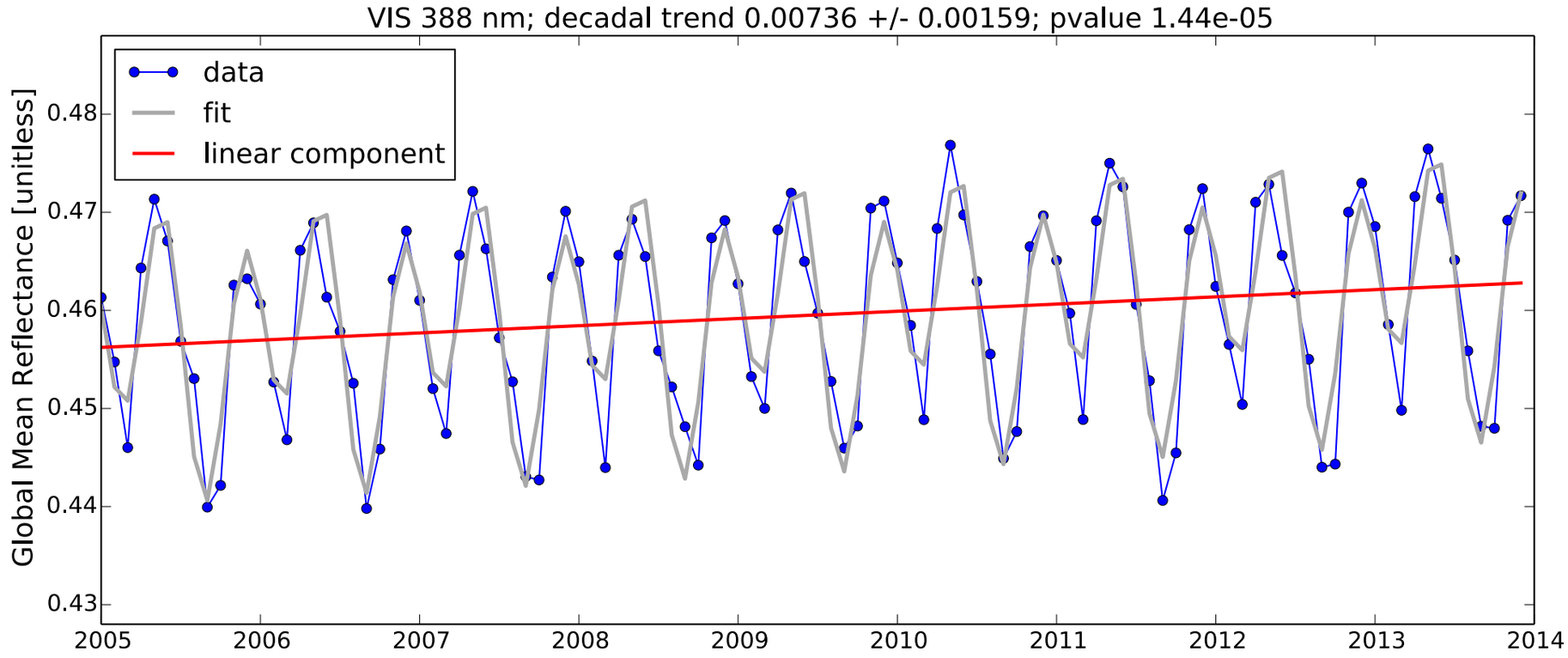
Glen Jaross & Sergey Marchenko

Radiometric Stability

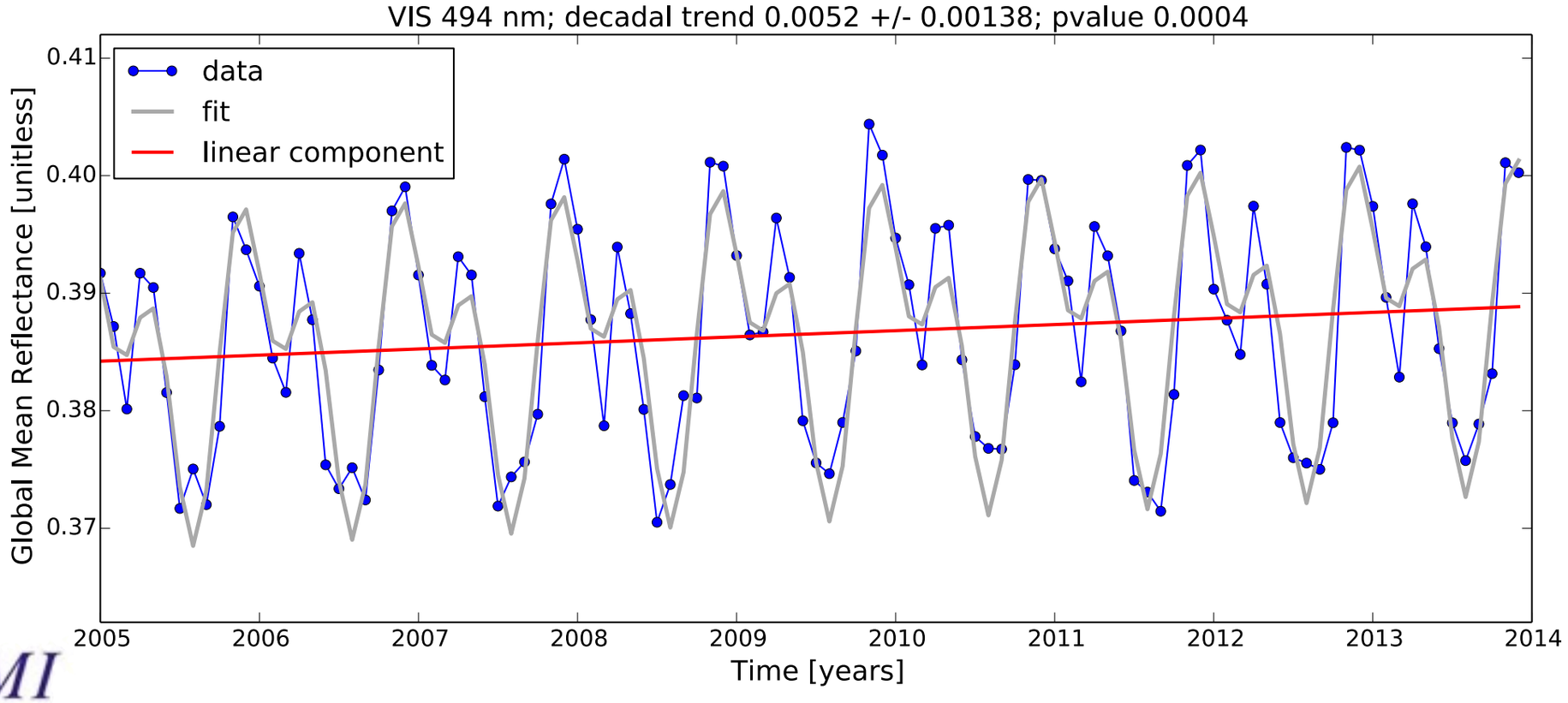
- It is not possible to derive the degradation of the individual optical components.
  - Assume a negligible degradation of the M2 and the spectrometer

	UV1	UV2	VIS
M1	-1%	-0.5%	-0.5%
D	-2.5%	-1.4%	-0.6%
FM	-2.0%	-1.6%	-1.7%
M2	0%	0%	0%
S	0%	0%	0%
E	0%	0%	0%
I/F	+3.7%	+2.6%	+1.8%
I/F	-1%	-0.5%	-0.5%

Mean Global Reflectance (area weighted)



+1.6%



+1.4%

OMI

EOS AURA
Chemistry & Climate

Summary

- OMI is a very stable instrument.
- The degradation is almost linear.
- Row anomaly affected data is flagged in the L1B product.